Using Microprocessors to Learn About their Environment

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One of the major advantages of microprocessors is that in any given project they allow a degree of "intelligence" and flexibilty not normally associated with conventional electronic controls. These functions may not be attainable at all with "discrete" electronics. Once the intelligence is present in the form of a microcomputer additional functions, outside those called for in the original specification, may be added at very little extra cost. In this paper I intend to present two examples of how this intelligence may be used to allow the microcomputer to learn about its environment. This results in one case as improved performance, and reduced maintenance, whilst in the other commisioning and duplication of the system is much simplified. In order to place the area of discussion in perspective both projects as a whole are dealt with in some detail.

Project 1

Feeding a set amount of powder product (by weight) into a container poses several problems. The speed with which the powder is fed into the container directly affects the accuracy of the weight of the product which finally ends up in the container. This is a result of the amount of product in the air. Conventional processes (figure 1) weigh the product in a weigh pan and then release it down a chute into the container. Depending on the product this could stick in the chute. Further inaccuracies occur from the build up of product on the weigh pan.

To solve these problems a different approach was suggested. The product (coffee) was to be fed into a rigid can. To gain speed the coffee was to be fed in at two separate stages. The first stage would allow a bulk fill to about 80% of weight and the second stage would trickle feed the remaining 20%. In between these two stages the product would be vibrated down to allow settling and make space for the additional 20%. The cans are queued and this allows the two processes to occur simultaneously. This solves the problem of inaccuracies due to the speed requirements ("in flight" product).

Being a rigid container each can is treated as a weigh pan. At the start of each feed cycle, each load cell (there are two required to attain the above process) is zeroed. This corrects for gradual build up of product of the load cell. The queue of cans is then shifted on. At the bulk fill stage the can is weighed so that at a later "stage" the amount of coffee in the can may be deduced. The product is then fed into the cans, which are resting on the load cells. As a result there is no product loss between the weigh pan and the can.

There are two stages of vibration between the bulk and trickle feeds, and the computer maintains a record of the can weights so that it knows this information when the can plus 80% of the total required weight arrives at the trickle feed stage. Figure 2 depicts this process.

To increase throughput 4 lanes run in parallel. The process runs under complete computer control, and the computer allows both random feeding of cans, and cans of varying weight within a particular range. It could also provide moving average information on the weights filled, and in the extreme even compensate the weights over a long term average to maintain the weights to the letter of the law, so there is an absolute minimum of give-away. This, however was not what I am trying to descibe, for the project was faced with a far more serious problem.

The output of the load cell, in the millivolt range, was fed through amplifiers into a A to D converter. To say that these amplifiers were inadequate would be an understatement. Aside from the noise rejection, they would drift over a period of a few hours altering the gain and zero, after having been set to the same amplification. Of course there was also long term variation in the characteristics of the load cells which was to be expected. The following solution could be applied, (somewhat less frequently) even in this case of only long term variation.

This variation in the amplification is critical, not because of the variaion at a bulk or trickle stage individually, but because of the interaction between them. As mentioned above the weight of the can is measured on the bulk stage. This information is then used at the trickle stage. Originally this value was measured and used in the computer as volts. i.e. if the can generated 2 volts equivalent at the bulk stage it was considered to be 2 volts at the trickle. If the amplification had changed this value serves no useful purpose.

The only way around this problem was by introducing a calibration mode where the computer would learn the characteristics of each load cell and its associated amplifer. Before going any further I would like to point out another advantage of using a microcomputer. No hardware change was required, (although was probably still desireable) all that was changed was the programme.

The principle used is from high school mathematics. If one knows two points on a straight line graph then the equation of the line can be calculated. In the calibration mode two cans of known weight are fed through the machine. For each load cell the output voltages (in binary representation) are recorded, and then the constants in the equation of the form (y=mx+c) are calculated for all 8 load cells. Once the voltage of the can is read it can now be converted to actual weight. This actual weight is used for the trickle stage, bypassing the vagaries of variations in the conversion to a binary representation. The more frequently the calibration is done the more the production will maintain its accuracy. In fact the computer could go into the calibrate mode

periodically of its own accord.

Project 2

In railway shunting yards there is a telephone on each signal post. This is to allow engine drivers to call into the control office to report where they are, plus to pass on any relevant information. Each telephone has its own number, much like a normal telephone. When the control centre wishes to communicate with a particular phone this number is "dialled". When a driver calls in the relevant number is displayed. There is also a mimic panel with a lamp at every location where there is a signal post telephone. The system catered for a total of 512 telephones, a considerable number of lamps!

Since there are a number of shunting yards scattered around the country it would be convenient if the central controlling computer could be adapted to allow different phone numbers to be set and to change location lamps on the mimic panel. Normally this would be set up as a table of constants in EPROM (Eraseable Programmeable Read Only Memory). Each lamp would have a set location to which it would have to be wired. If only 100 were connected, imagine the wiring problems that could arise. In future expansion each time a new telephone were to be added this would require an EPROM change and replacement, and installation, requiring switching off the system, new documentation, extra costs etc.

Commisioning could also be a problem since the system has 9 microcomputers and the setup according to a preordained (or possibly even unknown) set of telephone numbers could lead to severe problems.

To provide a solution the central computer is made capable of learning. Each lamp is connected to any output just as long as the two wires are connected in the correct polarity.

When a previously unrecognised signal post telephone calls in, the computer enters a special phase that allows the operator to enter the number he wants to be associated with that phone. The operator then steps through the mimic panel lamps until the required lamp is lit and instructs the computer that these are the parameters that are associated with the telephone. This information is then stored in some form of non-volatile memory.

All location dependant parameters can be done on the spot, and by relatively unskilled operators, provided the "learn" routine is simple enough. e.g. operator prompting.

Summary
In the first application I have tried to present how the computer can compensate for variation in its operating environment by using certain stimuli and adjusting its operation to the responses. The calibration procedure allows a non-skilled operator to calibrate the machine instead of a skilled technician to set up amplifications etc.

In the second application I have tried to show that the computer can learn so as to simplify installation procedures, and to make a particular solution or product more adaptable to different locations. It also means that a less skilled person can configure a system.

References:
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